National Aeronautics and Space Administration

Modeling Efforts with the OpenMDAO Framework

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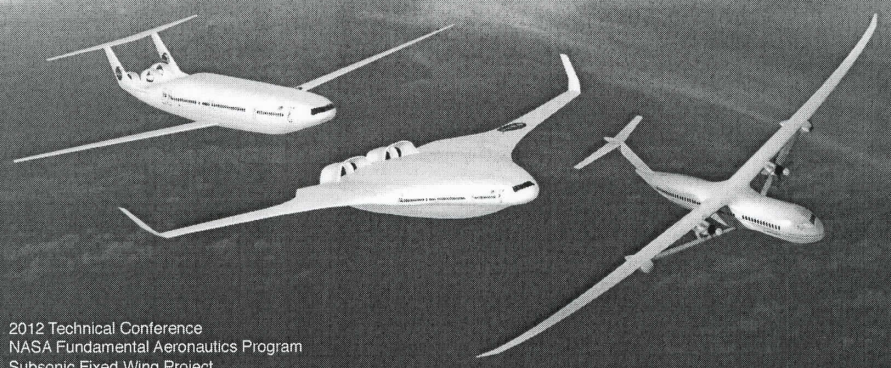


2012 Technical Conference
NASA Fundamental Aeronautics Program
Subsonic Fixed Wing Project
Cleveland, OH, March 13-15, 2012

www.nasa.gov

OpenMDAO Background

OpenMDAO.org

- Open source Multidisciplinary Design Analysis and Optimization (MDAO) Framework
- Built using the Python programming language
- Distributed under the Apache V2.0 open source license
- A research effort established with the goal of providing a common platform for MDAO that will help foster collaboration between industry, academia, and government

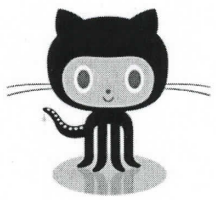
- Website: http://openmdao.org
- Source Code Repository: http://github.com/openmdao/openmdao-framework

Motivation

- Provide a common platform to expand the state of the art for MDAO through collaboration between industry, academia, and government
- Develop an MDAO framework that can support advanced MDAO algorithms to enable high-fidelity optimizations at all parts of the design process
- Encourage greater code re-use and software sharing in the MDAO field through the use of open source software development and distribution methods.

Open Source Software Community

- Released under the Apache V2.0 License
  - Extremely Permissive license which allows you to do almost anything
  - http://www.apache.org/licenses/LICENSE-2.0.html
  - Proprietary code can interface with OpenMDAO, without needing to be open source itself
  - Apache is compatible with the majority of other open source licenses out there
- Using Github as the portal for all community code contributions
  - Other software hosted on github.com: EGADS, GEM, GeoMACH, OpenMDAO official plugins
- Community forums: http://openmdao.org/forum
  - Active and growing user groups
  - Questions and answer style which encourages discussion



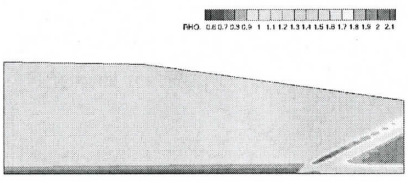
github
SOCIAL CODING

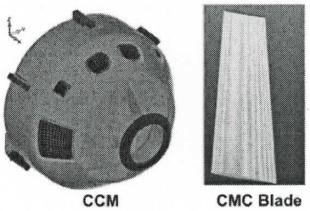
New Features in the Framework

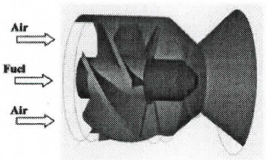
- OpenMDAO v 0.2.3 released, April 2012
- New Optimizers: SLSQP, COBYLA, PyOpt, IPopt
- Support for components with analytic derivatives
- Automatic implementations of MDAO Architectures:
  - IDF, MDF, CO, BLISS,BLISS-2000
- Greater support for High Performance Computing
- Easy installation of OpenMDAO plugins from the github plugins repository: http://github.com/openmdao-plugins
- Support for Python 2.7

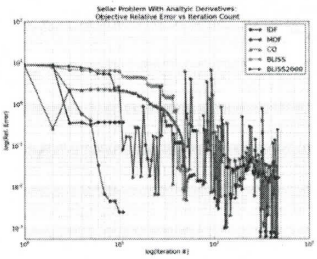
Modeling Efforts with OpenMDAO

- Working with researchers from Subsonic Fixed Wing and Supersonics to enable new research with MDAO methods



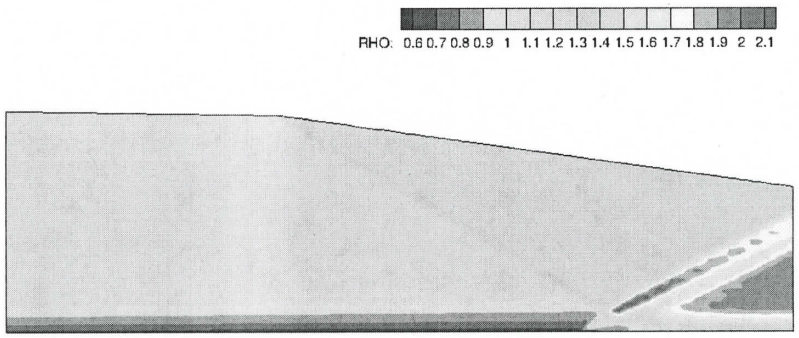






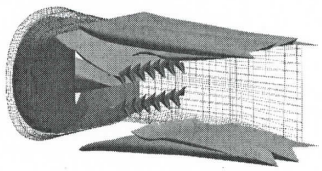
Modeling Efforts: Supersonic Inlet

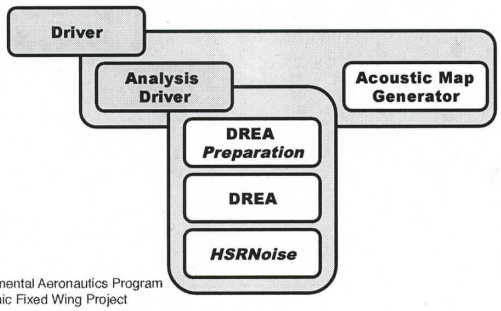
- Supersonic Inlet Geometry Optimization with Overflow
  - Wrapper for Overflow V2.2 available on http://github.com/openmdao-plugins
- Model built to investigate the optimal location and size for bleed holes in the inlet flow path
- Execution run remotely via High Performance Compute Cluster



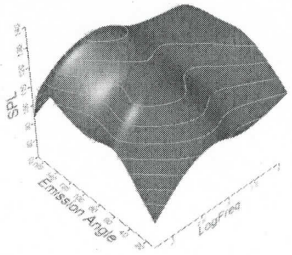
Modeling Efforts: Mixer-Ejector Nozzle

- Goal: develop a multidisciplinary analysis providing performance and acoustic maps for system level analysis
- Low fidelity analysis tools
  - Mixer-ejector performance: DREA
  - Mixer-ejector acoustics: HSRNoise
- Multidisciplinary analysis capability has been demonstrated for a notional design

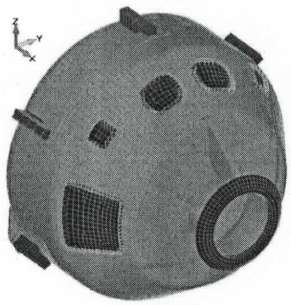




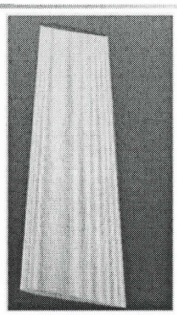
SPL Values for the Flyover Observer



Modeling Efforts: Structural Optimization



CCM

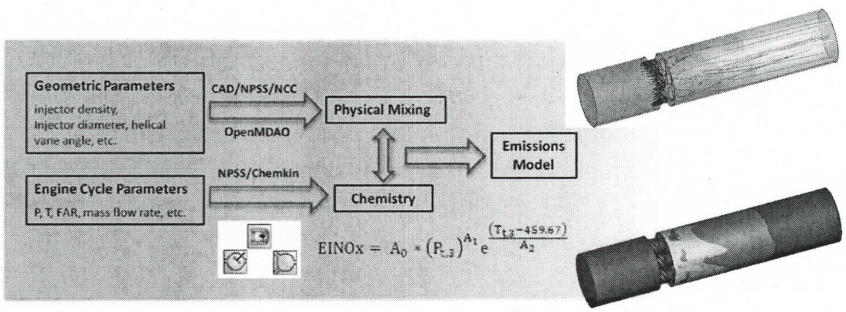


CMC Blade

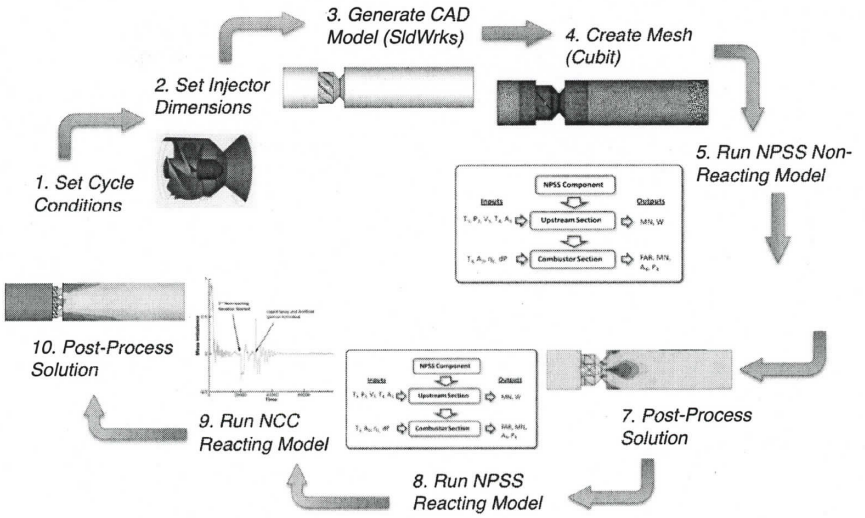
- Wide Range of Different Finite Element Models: Composite Crew Module, 25 Bar Truss, Turbine Blades
- Deterministic and stochastic structural optimizations
- Experimenting with optimization strategies using multiple optimizers
- Working with multi-objective optimizations

Modeling Efforts: Lean Direct Injection

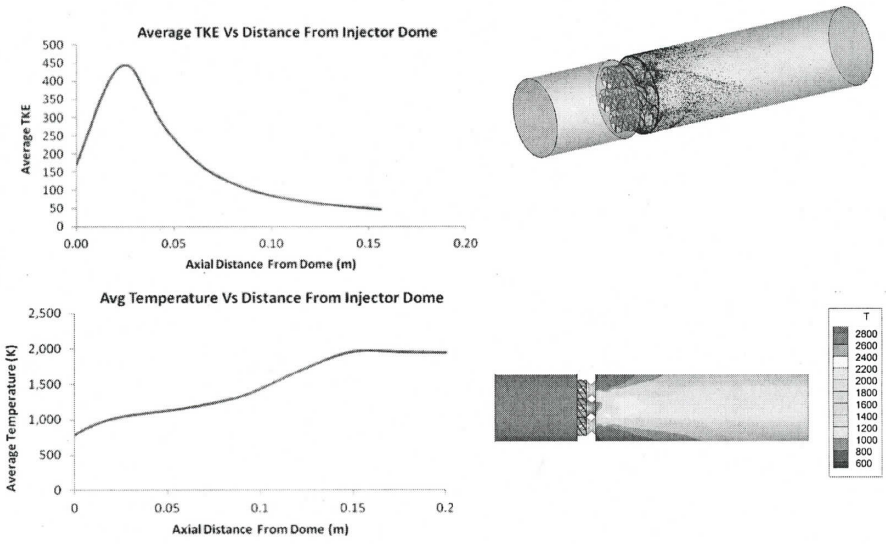
- Multi-fidelity modeling effort, using NPSS and NCC
- Tight integration with Solidworks parametric geometry
- Design space includes major topological changes to geometry



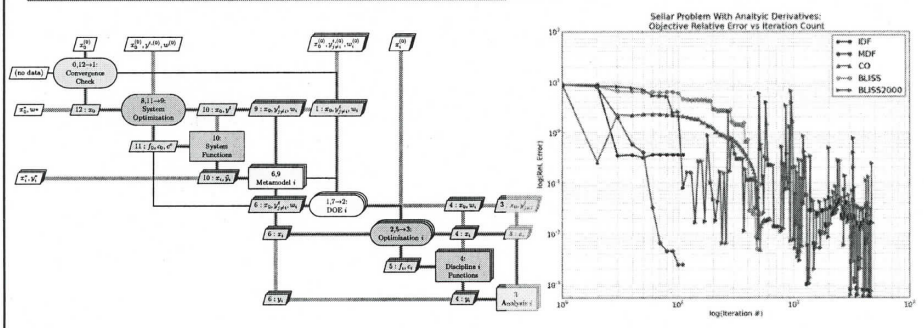
Modeling Efforts: LDI cont.



Modeling Efforts: LDI cont.



Modeling Efforts: MDAO Benchmarking



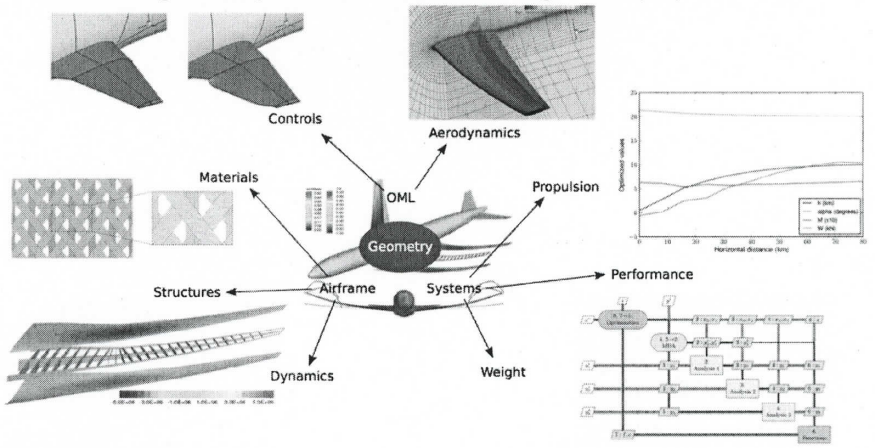
- Using OpenMDAO for standardized MDAO architecture testing
- Implemented IDF, MDF, CO, BLISS, BLISS-2000
- Automatically apply MDAO architectures to any problem
- Building a suite of test problems to test architectures against
- Working with AIAA MDO Technical Committee to expand test suite.

Integrating Geometry Capabilities

- Developing a tight integration with multiple geometry tools via a common interface
- NRA Effort: University of Michigan, MIT:
  - GeoMACH: open source conceptual geometry engine suitable for optimization with high fidelity analysis tools
- NRA Effort: MIT, Syracuse University:
  - EGADS: Utility for interfacing with OpenCASCADE kernel
  - OpenCSM: open source CAD based approach to geometry for MDAO
  - Geometry Engine for MDAO (GEM): universal interface for working with geometry tools

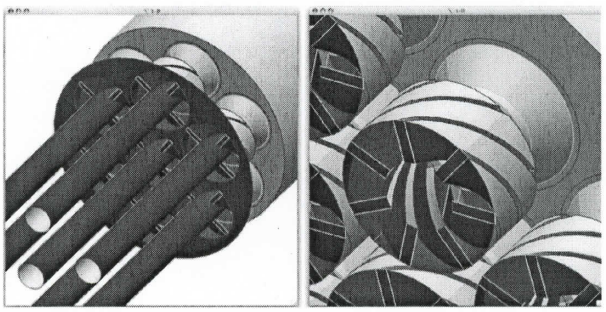
GeoMACH

- PI: Dr. Martins, University of Michigan
- Fast b-spline based geometry generation with analytic derivatives
- Produces geometry suitable for use with high fidelity optimizations



OpenCSM and EGADS

- PI: Robert Haimes, MIT; CO-PI: Dr. Dannenhoffer, Syracuse University
- CAD based approach to geometry generation
- Support for Analytic Derivatives
- EGADS provides services to access the OpenCASCADE Kernel
  - OpenCSM uses EGADS to talk to OpenCASCADE geometry Kernel
  - OpenVSP project is using EGADS for STEP file output capability
  - GeoMach links with EGADS to provide an efficient link to the GEM API



Geometry Environment for MDAO (GEM)